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CORRELATION IN THE INFLORESCENCE OF CELASTRUS SCANDENS.

BY J. ARTHUR HARRIS.

Data supplementary to those presented in the preceding papers are to be found in my notes on the inflorescence of *Celastrus scandens*. Since I have not now the time for collecting sufficiently numerous and varied series of material for a comprehensive study of variation and correlation in the inflorescence it seems best to publish the rather diverse notes which I have under separate titles which shall indicate the species examined as well as the subject considered.

In the fall of 1905, 386 clusters of the fruit of *C. scandens* were collected in the woods a little north of Jefferson Barracks, Mo. All of these were taken from one clump of vines. Whether these were parts of the same individual or whether more than one plant was involved was not definitely determined at the time. The fruits were gathered primarily to secure a variation curve for number of seeds developing per fruit, and the problems connected with the inflorescence presented themselves later. At that time, too, like most biologists I was unacquainted with the importance of knowing definitely the number of individuals from which material for quantitative investigation is taken. Presumably only a single plant was involved, but we do not *know* this to be true. And so far as I am able to see this unfortunate omission in our observations does not affect in any way the validity of any conclusions drawn in this paper, although it has necessitated the neglecting of certain other points which might have been considered had our knowledge of this point been definite.

These fruits are very easily worked with. A transverse section quickly made with a razor, shows at a glance the number of seeds which have developed. The normal number of cells in this collection of material was three, and two seeds sometimes developed in each locule. The maximum normal number of seeds was assumed to be six. In sectioning

2541 fruits, only two were found in which the fruit was four-celled and the number of seeds greater than 6. Of course it is impossible to say that more than 6 ovules might not have been produced in any of the fruits which bore 6 seeds or fewer. It seemed best to regard these two cases merely as teratological; the two clusters upon which they were borne were therefore discarded, and only 384

TABLE I. CELASTRUS.

Fruits Matured per Inflorescence.																									
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Totals	
Flowers per Inflorescence	4	..	2	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	
	5	..	1	2	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	
	6	..	3	1	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	
	7	1	5	4	..	2	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	13	
	8	1	11	5	6	..	..	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	27	
	9	1	9	6	11	3	2	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	37	
	10	1	5	9	3	9	3	3	1	2	..	..	..	..	..	..	..	..	..	..	..	..	..	36	
	11	..	5	4	10	5	8	1	1	2	1	2	..	..	..	..	..	..	..	..	..	..	..	37	
	12	..	7	8	5	9	9	3	6	4	1	2	..	..	..	..	..	..	..	..	..	..	..	54	
	13	..	4	6	4	6	6	6	2	4	3	1	1	..	..	..	..	..	..	..	..	..	..	43	
	14	1	1	6	3	2	5	2	5	3	2	4	2	2	2	..	..	..	..	..	..	..	..	38	
	15	..	1	4	4	4	2	3	3	5	5	4	2	..	2	1	..	..	..	..	..	..	..	..	36
	16	..	1	2	5	2	1	3	2	..	2	1	4	..	..	..	..	..	..	..	..	..	..	..	23
	17	..	1	..	1	..	3	3	1	1	..	1	..	1	1	..	..	..	..	..	..	..	..	..	13
	18	..	..	..	..	..	..	1	1	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	4
	19	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	1
	20	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1	..	..	2	..	..	..	..	..	4
	21	..	..	..	1	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	2
	22	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
	23	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
	24	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	
	Totals		5	56	60	55	42	41	34	24	21	14	11	7	6	4	1	..	2	..	..	..	..	1	384

CORRELATION FOR FLOWERS AND FRUITS.

used for the statistical study. Since that time I have found *Celastrus* in which 4-celled fruits occurred very frequently, and it is possibly unfortunate that the two inflorescences bearing these aberrant fruits were discarded. But it is certainly not worth while to go to the labor of inserting them into the tables.

The number of fruits per inflorescence is quite variable, ranging in the present sample from 2 to 23. The first

question which arises is that concerning the relationship between the number of flowers formed and the number of fruits maturing per inflorescence. Unfortunately it is not possible to determine with absolute certainty the number of flowers formed from an examination of the mature fruit clusters. But from the scars left by the falling of the flowers failing to develop mature fruits it is possible to obtain a pretty close approximation, and I venture to publish the data after warning the reader that the frequencies are perhaps not absolutely trustworthy, though the best we could determine under the circumstances.

Table I shows the correlation between the number of flowers formed and the number of fruits maturing on the 384 inflorescences of our sample. The constants which are of service are:

Mean number of flowers	11.948 $\pm$.110
Standard deviation of flowers	3.202 $\pm$.078
Coefficient of variation of flowers	26.80
Mean number of fruits	6.578 $\pm$.110
Standard deviation of fruits	3.196 $\pm$.078
Coefficient of variation of fruits	48.58

The coefficient of correlation between the number of flowers formed and the number of fruits developing is

$$r = .572 \pm .023.$$

The degree of interdependence between these two characters is therefore very considerable. But isolated constants of this kind are of little interest; to give them the greatest significance a sufficient number of such correlations should be worked out to make the problem a comparative one. It will be of considerable physiological interest, I imagine, to determine how closely the number of fruits developing per inflorescence in distinct species, or in series of the same species taken in different habitats, is dependent upon the number of flowers formed. The only case available for comparison is that of the immature inflorescence of *Staphylea* * where we find a correlation of about 0.46. With a beginning once made, data of this kind will gradually accumulate.

* Harris, J. A. *Biometrika*. 6 : 441. 1909.

For present purposes the constant of most significance is not that for the relationship between the number of flowers formed and the actual number of fruits developing per inflorescence, but between the number of flowers formed per inflorescence and the deviation of the number of fruits developing per inflorescence from the number which would have developed had the number of fruits per inflorescence been merely proportional to the number of flowers formed in a ratio determined by the total number of flowers and fruits in the population as a whole. This constant shows us at once whether there is on the whole any difference in the capacity of the inflorescences for developing their ovaries into fruits depending upon the number of flowers of which they are composed. When I pointed out the desirability of such a constant as this to Professor Pearson while working in his laboratory he kindly worked out the mathematical formulae necessary.

The constant* is calculated from the formula

$$r_{xz} = \frac{r_{xy} - V_x/V_y}{\sqrt{1 - r_{xy}^2 + (r_{xy} - V_x/V_y)^2}},$$

where x =flowers and y =fruits per inflorescence, V_x and V_y are the coefficients of variation of the two characters, and z is to be read as "the deviation of the number of fruits per inflorescence from its probable value."

Substituting constants in the above formula we find

$$r_{xz} = .024 \pm .034$$

This constant, differing from 0 by less than its probable error, shows at once that there is no sensible difference in the capacity of inflorescences with different numbers of flowers to mature their fruits. The results are not at all in accord with those for the only other inflorescence so far investigated with regard to this point, the *Staphylea* series above referred to. There we found a considerable positive correlation between the actual number of flowers formed and fruits maturing, but a marked negative correlation of about $-.65$ between the number of flowers per inflorescence and the devia-

* Harris, J. A. *Biometrika*. 6: 439. 1909.

tion of the number of fruits formed from their probable value. But it will be recalled that in the case of *Staphylea* the process of elimination of ovaries was not yet complete. In the original paper I remarked: "It may be found later that after the elimination is complete the correlation between the number of flowers and the deviation of the number of fruits per inflorescence from their prob-

TABLE II. CELASTRUS.

Number of Seeds per Fruit.								
		1	2	3	4	5	6	Totals
Number of Flowers per Inflorescence	4	5	7	4	.....	1	1	18
	5	.....	2	4	1	7	2	16
	6	1	7	7	6	1	2	24
	7	3	8	5	14	12	10	52
	8	4	17	11	36	33	16	117
	9	5	20	32	56	44	23	180
	10	4	22	38	52	57	23	196
	11	4	16	42	60	62	31	215
	12	4	34	71	94	97	48	348
	13	6	31	63	81	68	49	298
	14	7	23	68	77	81	50	306
	15	7	26	66	87	66	50	302
	16	3	12	34	52	50	32	183
	17	2	9	22	32	28	20	113
	18	.....	5	13	20	6	3	47
	19	.....	.....	1	1	3	1	6
	20	3	6	13	16	16	8	62
	21	.....	1	9	3	6	1	20
	22	.....	.....	.....	.....	.....	.....	.....
	23	.....	.....	.....	.....	.....	.....	.....
	24	2	1	8	7	4	1	23
	Totals	60	247	511	695	642	371	2526

CORRELATION FOR FLOWERS PER INFLORESCENCE AND SEEDS PER FRUIT.

able number will rise to sensibly 0, or take a substantial positive value." I am anxious to see many other series of comparable material collected and reduced for comparison with these.

The second question to demand solution is; What relationship, if any, is there between the number of flowers formed per inflorescence and the number of seeds in the fruits of an inflorescence? The same question is to be asked

concerning the relationship between number of fruits maturing per inflorescence and number of seeds maturing per fruit.

If the inflorescences with larger numbers of flowers or fruits represent the more vigorous fruiting axes, it seems not unreasonable to suppose that they might mature more seeds per fruit than the smaller axes. No originality is claimed for this suggestion. The idea seems to be held in one form or

TABLE III. CELASTRUS.

Number of Seeds per Fruit.								
		1	2	3	4	5	6	Totals
Number of Fruits per Inflorescence	2	.....	1	.....	3	2	4	10
	3	6	24	32	48	37	21	168
	4	7	27	54	59	49	44	240
	5	3	32	54	82	78	26	275
	6	6	30	55	57	64	40	252
	7	5	31	42	90	76	43	287
	8	6	21	43	81	77	44	272
	9	.....	13	45	62	54	42	216
	10	8	19	49	56	57	21	210
	11	8	20	37	33	35	21	154
	12	.....	7	29	31	40	25	132
	13	2	3	10	25	31	20	91
	14	1	6	21	28	17	11	84
	15	3	3	16	19	14	5	60
	16	.....	3	7	6	.....	.....	16
	17	.....	.....	.....	.....	.....	.....	.....
	18	3	6	9	8	7	3	36
	19	.....	.....	.....	.....	.....	.....	.....
	20	.....	.....	.....	.....	.....	.....	.....
	21	.....	.....	.....	.....	.....	.....	.....
	22	.....	.....	.....	.....	.....	.....	.....
	23	2	1	8	7	4	1	23
	Totals	60	247	511	695	642	371	2526

CORRELATION FOR FRUITS PER INFLORESCENCE AND SEEDS PER FRUIT.

another by a number of botanists with whom I have talked. Some even seem to consider that it is so self-evident that there should be a correlation between the size of the individual—in the case of annual plants—and the fertility of its fruits, or between the size of the inflorescence and the fertility of the fruits that it is hardly worth while to take up an actual investigation of the problem.

Tables for the correlation between the number of flowers per inflorescence and the number of seeds per fruit, and for the number of fruits developed per inflorescence and the number of seeds per fruit, are given under the numbers II and III. The possibility of some uncertainty concerning the number of flowers formed will be borne in mind.

In these tables the numbers of flowers formed and fruits developing are necessarily weighted with the number of fruits which they actually produce. In calculating the correlation coefficients, standard deviations based on these weighted frequencies were calculated, but it seems unnecessary to publish them here. The constants for number of seeds per fruit are:

Mean	$4.0788 \pm .0172$
Standard deviation	$1.2817 \pm .0122$
Coefficient of variation	31.422

The relationship between number of flowers per inflorescence and number of seeds per fruit, and between number of fruits developing per inflorescence and the number of seeds per fruit are:

Number of flowers and number of seeds, $r =$	$.033 \pm .013$
Number of fruits and number of seeds, $r =$	$-.012 \pm .013$

Possibly the first of these coefficients is significant with regard to its probable error; the second is certainly not. In the calculation of these probable errors, N was taken as the actual number of fruits involved in the correlation table. If we consider that the degree of trustworthiness of our work is determined rather by the number of inflorescences, our probable errors will be so raised that neither of these constants can possibly be regarded as significant. The fact that one is positive and the other negative also raises some doubt as to their significance.

We conclude therefore that, so far as the data now available for this species enable us to determine, there is neither sensible interdependence between the number of flowers formed on an inflorescence and its capacity for maturing the ovaries of these flowers into fruits nor sensible relationship between the size of an inflorescence as measured by the number of flowers it produces and the number of seeds per fruit.